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INTRODUCTION AND DEVELOPMENT OF A DRYLAND CROP RIPARIAN CONSERVATION PROJECT

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Abstract

Native riparian areas in the dryland crop regions of the intermountain Pacific Northwest largely have been eliminated during the last 140 years. Native riparian grass, shrub, and tree species found on broad flood plains have been replaced by introduced species growing in narrow, incised channels. Owners of 2.2 km of Gerking Creek located near Athena, Oregon are working to reestablish a riparian community in former cropland, known as the Gerking Flat project. This effort requires an evaluation of present conditions and constraints imposed by existing vegetation, channel morphology, and management. We quantified valley bottom landform and channel development by establishing 22 channel cross-sections and developing a detailed contour map of the site. Reestablishment of a riparian community will depend upon changes in upland and channel management. Establishment of a buffer strip between cropland and channel will address excessive sediment delivery from the upland area within the project and the adjoining fields. However, Gerking Creek will continue to be a source of considerable sediment and energy associated with concentrated flow. Channel adjustment can be expected to continue in the form of deposition, headcut migration, channel migration, and bank sloughing. These processes can tear out newly planted material and alter soil-water relationships in the riparian area. Among the alternatives available for the Gerking Flat Project are: (1) to leave the channel within the project area to develop on its own, or (2) to design a channel with reduced stream slope, a raised stream bed, and increased meander frequency.

Keywords: riparian; agriculture; Conservation Reservation Enhancement Program

Introduction

Native riparian areas in the dryland crop region of north central Oregon, eastern Washington, and western Idaho largely have been eliminated during the last 140 years. These areas, characterized by broad, shallow bottoms occurring on low gradient second and third order streams, first were used as pasture land for livestock, particularly draft horses, mules, and oxen. Judging by the native vegetation and namesake of some creeks flowing through these bottomlands (e.g., Greasewood Creek) the soils were naturally salt affected. With mechanization, a few of these pastures were retained for small herds of cattle and saddle horses, but most were cleared, plowed, and entered into the winter wheat (*Triticum aestivium,* L.)./summer fallow or annual cropping systems common in this region. These channels, often straightened, are cleaned regularly of vegetation to facilitate the efficient removal of water and soil from adjacent roads and fields. Introduced vegetation now grows on narrow floodplains in incised channels where native riparian grass, shrub, and tree species on broad floodplains once thrived. Storm flow, concentrated in time and space, causes rapid soil loss through bank failure and down cutting. Excess energy exacerbates problems downstream during flood events.

In the 1960s, 44.5 ha of native prairie bottomland on Gerking Flat, near Athena, Oregon, were brought into production as a winter wheat/summer fallow rotation. Although the wheat/fallow system, which is prevalent in the intermountain Pacific Northwest (PNW), reduces the risk of crop failure resulting from inadequate soil moisture, it exposes soil to erosive forces (rainfall and wind) during late fallow and early crop establishment. Soil erodibility is increased further because of soil organic matter loss, which occurs during the non-productive part of the rotation (Rasmussen et al., 1993).

After the 1964 Christmas flood, Gerking Creek was straightened to ease use of farm machinery, to aid in early soil drainage for equipment access, and to reduce the impact of salt accumulation on crop production. Despite these efforts, an increase in soil pH and a decline in wheat yields were observed, and barley, a more salt tolerant crop, was planted. However, by 1998, the land was removed from production because barley yields had decreased to such an extent that it was no longer economical.

Due to environmental concerns regarding the impact of soil erosion on watershed fish and wildlife habitat, landowners' desire to enhance wildlife habitat, and continued crop production problems associated with salt affected soil, this portion of Gerking Flat was entered into the Conservation Reservation Enhancement Program (CREP) for 15 years, beginning in 1999. CREPs are managed and funded through the USDA-Farm Service Agency. This project is a cooperative effort amongst landowners, the USDA-Natural Resources Conservation Service (NRCS), the Umatilla Soil and Water Conservation Districts (SWCD), and Pheasants Forever. Concern that Gerking Creek, an intermittent stream, can destabilize the current stream banks during high flows and produce high erosion rates resulted in a plan to plant the active stream channel to a population density of 500 live trees per ha, to be assessed 3 years following planting. The stream was divided into three vegetation zones: (1) the active stream channel, which will be planted to cottonwoods; (2) the floodplain, which will be planted to willows; and (3) the upland area, planted to a mix of native grasses and forbs. A species list is supplied as Appendix 1.

Establishment of a riparian community requires an evaluation of current conditions and constraints imposed by current vegetation composition, channel morphology, and changes in management. For example, planting trees in or near the current channel might result in stabilizing the channel location, or the shrubs and trees might trap enough soil to force the channel well away from the planted area. Although more sinuosity ultimately might be an objective, in the early phases of the project, channel movement away from newly planted vegetation might be considered a failure. Our objectives for this paper were to introduce the Gerking Flat CREP project, its goals, the initial stages of riparian community potential and channel analysis, and the unique research opportunities that will develop around this and other CREP projects on the Columbia Plateau. Our quantification of current channel conditions will be used to aid in developing a plan to ensure successful reestablishment of a riparian corridor and will aid in designing changes in channel plan form to create a more stable channel.

Methods

Gerking Creek is a third order stream (Strahler 1952) and tributary of Wildhorse Creek, a tributary of the Umatilla River, which is a tributary of the Columbia River. The Gerking Flat CREP is located on Gerking Creek, approximately 6.4 km from the confluence of Wildhorse Creek, and 7.2 km west-northwest from Athena, Oregon (45° 50' 30" N, 118° 32' 30" W). The portion of Gerking Flat within the project area is owned by five landowners.

Meteorological records at USDA-ARS Columbia Plateau Conservation Center, located approximately 14.4 km southwest of the research site, show 39-year minimum, maximum, and mean annual temperatures of -34°C, 46°C, and 11°C, respectively. Frost-free days range from 135 to 170. Approximately 70 percent of precipitation occurs between November and April, and results from maritime fronts that produce low intensity storms with a median duration of 3 hours, 50 percent lasting 1 to 7 hours. From 1994 to 1998, annual precipitation departures from the 69-year average (418 mm) recorded at CPCRC were -24 percent, +27 percent, -16 percent, +32 percent, and +8 percent. Frozen soil, with or without snow cover, is transient and melts rapidly with the frequent arrival of warm maritime fronts. This area experiences from 0 to 7 (median = 3), freeze thaw events annually (Zuzel 1994).

Soils are Hermiston silt loams (coarse-silty, mixed, mesic Cumulic Haploxeroll) formed in silty alluvium from loess and ash on flood plains and low terraces, with slopes ranging from 0 to 3 percent (Johnson and Makinson, 1988). These soils overlie the basalt layers of the Columbia Plateau, which formed in the Miocene age.

We surveyed the channel and associated bottomland with GPS survey grade equipment. The survey was conducted using a Trimble GPS TS 4400 and processed using Trimble and Autodesk software[1]. Data used to construct a model of Gerking Flat, channel cross sections, and headcuts (vertical channel adjustments) were collected using real-time kinematic (RTK) data acquisition with a horizontal precision of 10 mm ± 2 ppm and a vertical precision of 20 mm ± 4 ppm.

The results presented below summarize the data collected for this project to date; the final analysis and interpretation of the full data set has yet to be performed. The current flood plain is interpreted from the survey data; there are no flow records for Gerking Creek. We report sinuosity, channel slopes, headcut locations, width to depth ratios (w/d) for degree of channel incision into the valley floor, and bankfull w/d ratios. Sinuosity is defined as the stream length divided by valley length ($P = \lambda/L$), where $P = 1$ for a straight channel. Channel slope is the elevation change over the length of the studied stream section. Headcuts are sites where channel slope is adjusting to energy and stream length relationships. W/d ratios of channel incision are a description of the downcutting into the valley floor by the stream. Bankfull w/d ratios are determined from cross-sectional evidence of recently formed terraces within the incised channel.

[1] Use of product names does not constitute endorsement by the USDA, Umatilla SWCD, or Oregon State University.

Results

The channel length through the CREP is 2,232 m: 2,072 m composed of a single thread channel and 160 m in a multiple thread channel. The project area ranges in elevation from 571 to 587 m (Figure 1). Sinuosity is 1.1, and average channel slope is 0.8 percent, ranging from 0.16 to 4.00 percent within the project (Table 1). Headcuts were found and measured at river stations 7.04, 7.41, and 7.56 km, and three of the 22 established channel cross sections are located at river stations 6.77, 7.29, and 8.41 km (Figure 2). Nearly the entire length of single thread channel is incised within Gerking Flat (Figure 3). Valley form width to depth (w/d) ratios are ~ 11.5 into the valley bottom below the multiple thread section, whereas the w/d ratio above is ~ 6.1. Within the multiple thread section, the w/d ratio is 48.1. The remnant of an abandoned channel rejoins the current active channel at 6.95 km. This channel currently carries spring flow and appears to also carry water during extremely high flows that overtop the 1.5 m channel bank at river station 7.40 km. Bankfull w/d ratios are ~ 8.3 below and ~ 22.0 above the multiple thread section, and ~ 15.9 within the multiple thread section (Figure 4).

Table 1. Channel slope throughout Gerking Flat Conservation Reservation Enhancement Project.

River Station (m)	Elevation (m)	Slope (%)	Average channel slope (%)
8,600	586.0	4.00%	
8,500	582.0	0.37%	
7,550	578.5		
7,550	578.0	1.33%	
7,400	576.0	0.16%	
7,275	575.8	0.32%	
7,025	575.0	0.91%	
6,750	572.5	1.00%	
6,600	571.0	2.00%	
6,500	569.0	0.50%	
6,400	568.5		0.80%

River station is distance from confluence with Wildhorse Creek.

The incised reaches are populated with cattails (*Typha latifolia* L.), Russian thistle (*Salsola iberica* Sennen & Pau), Kochia (*Kochia scoparia* L.), downy brome (*Bromus tectorum*), and drop seed. The multiple thread section, farmed until 1998, contains both downy brome and Sand dropseed (*Sporobolus cryptandrus* Torr.), and a mix of native

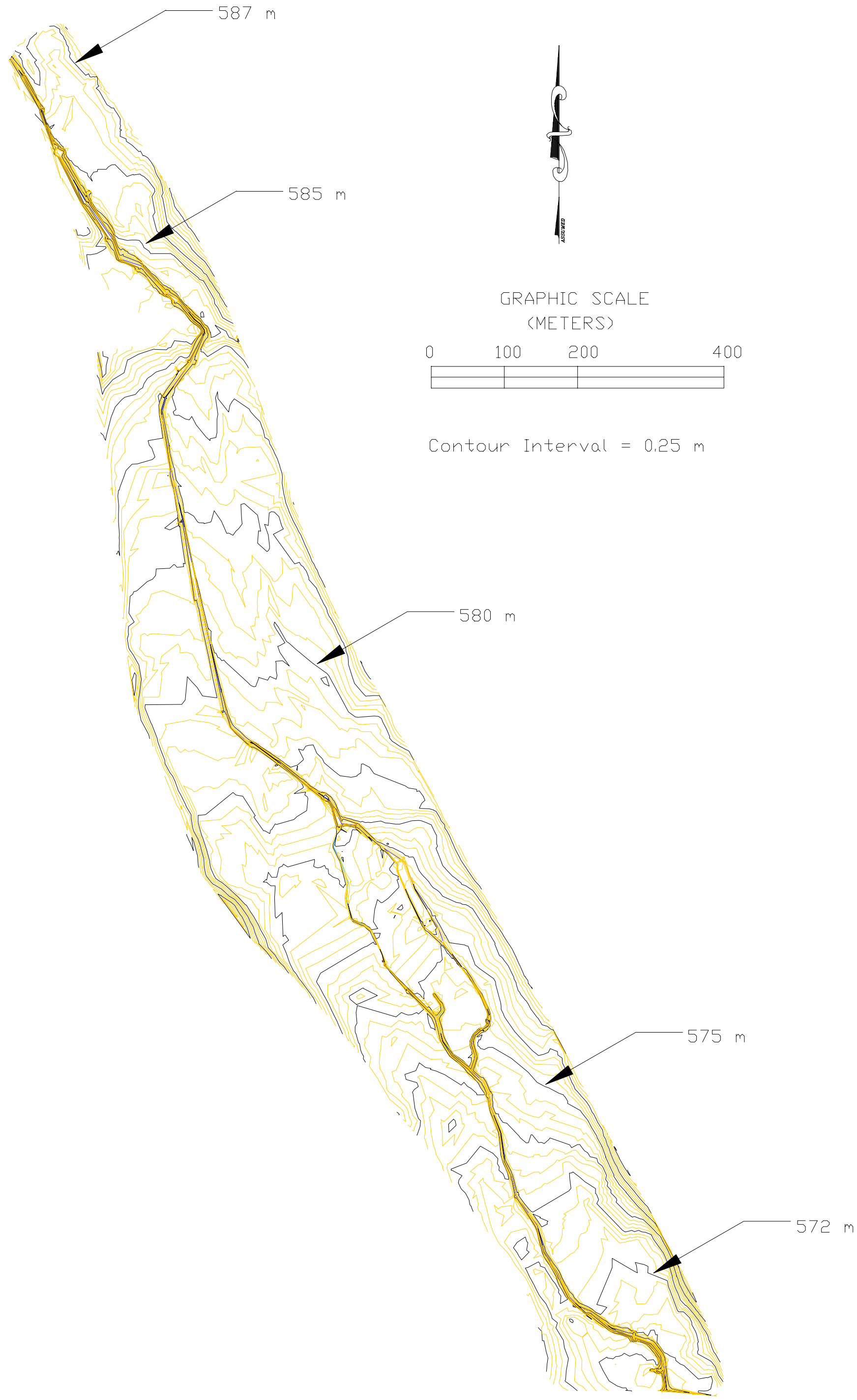


Figure 1. Gerking Flat Conservation Reserve Enhancement Project area, contour interval ~ 0.25 m. West side of project area bounded by low hills and cropland, east side bounded by county road and cropland. Predominate channel form is incised single thread.

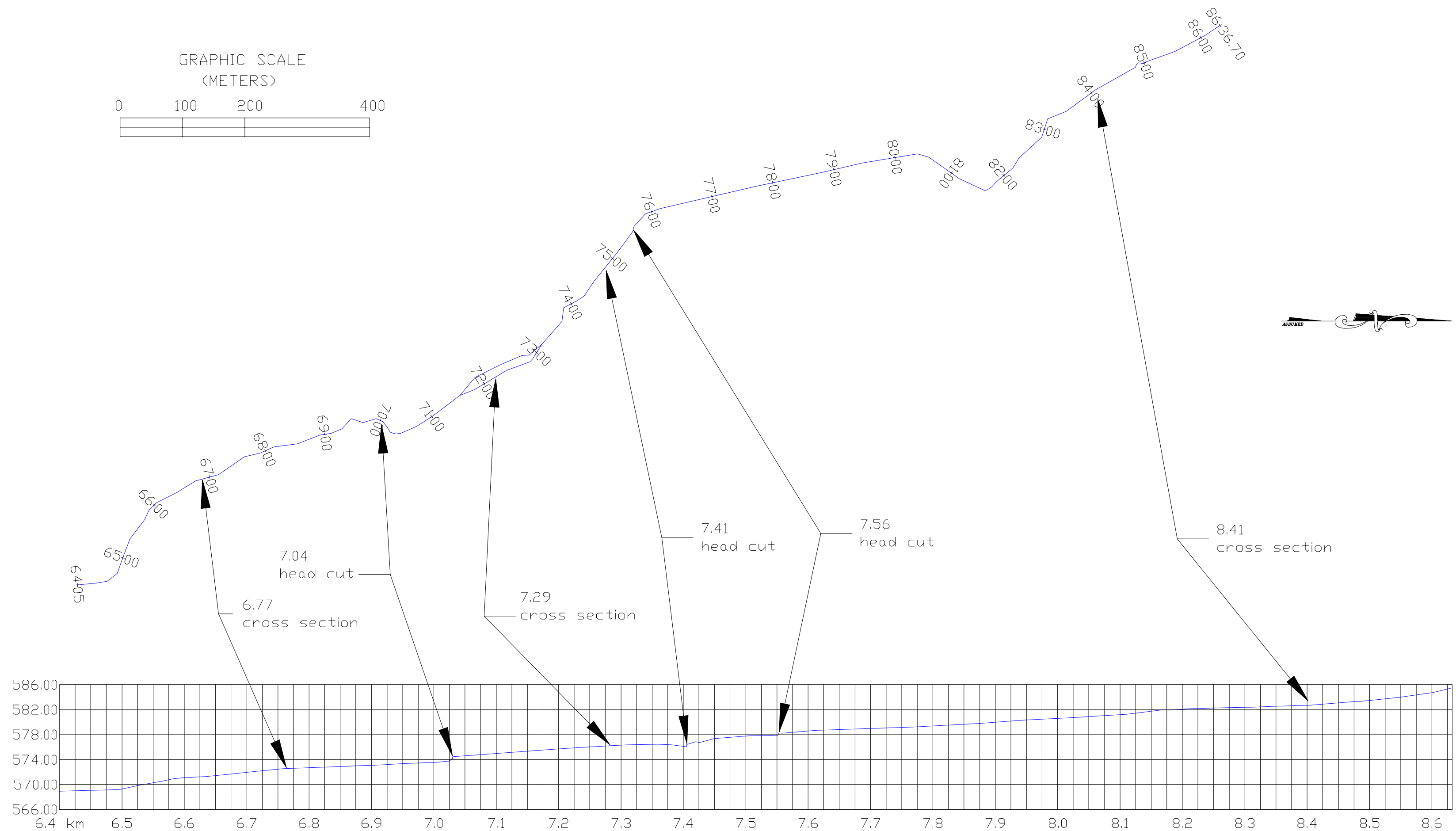
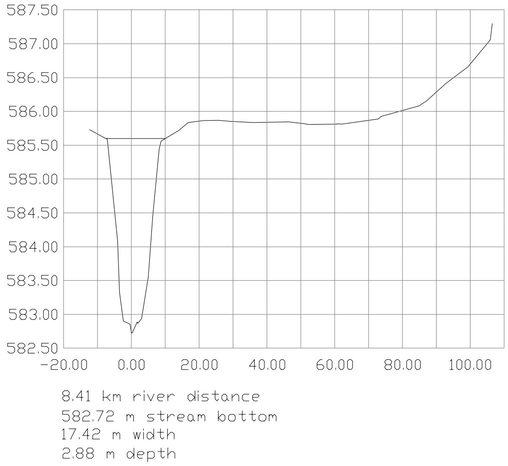
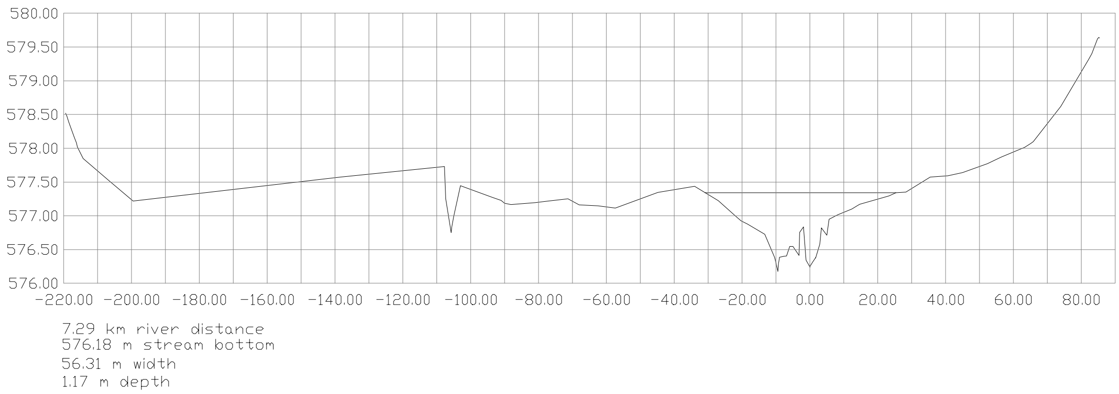


Figure 2. Plan view and stream profile of Gerking Creek through Gerking Flat Conservation Reserve Enhancement Program project. River stations are meter distance from confluence with Wildhorse Creek. Three headcuts present in project and three of 22 channel profile cross-sections are identified by location on plan view and profile.





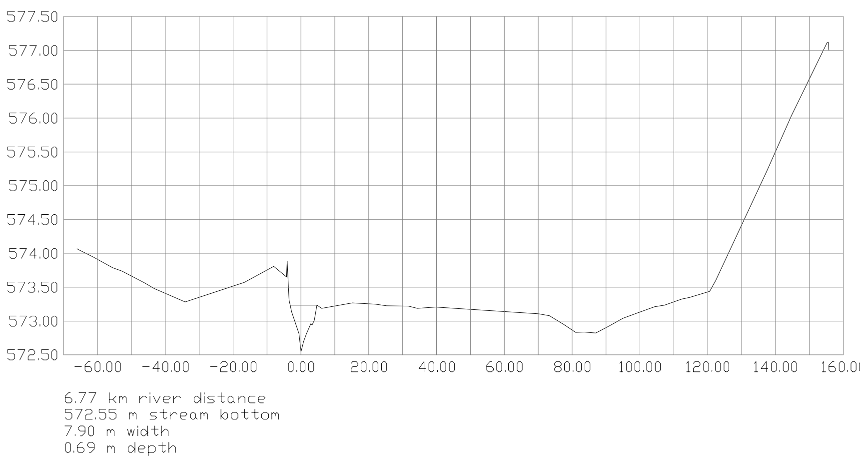


Figure 3. Gerking Creek incision into Gerking Flat within Conservation Reserve Enhancement Program area. Flow is from page, vertical exaggeration is 5x. River distance is from Wildhorse Creek confluence, stream bottom is elevation. Depth measured from estimated pre-incised surface.

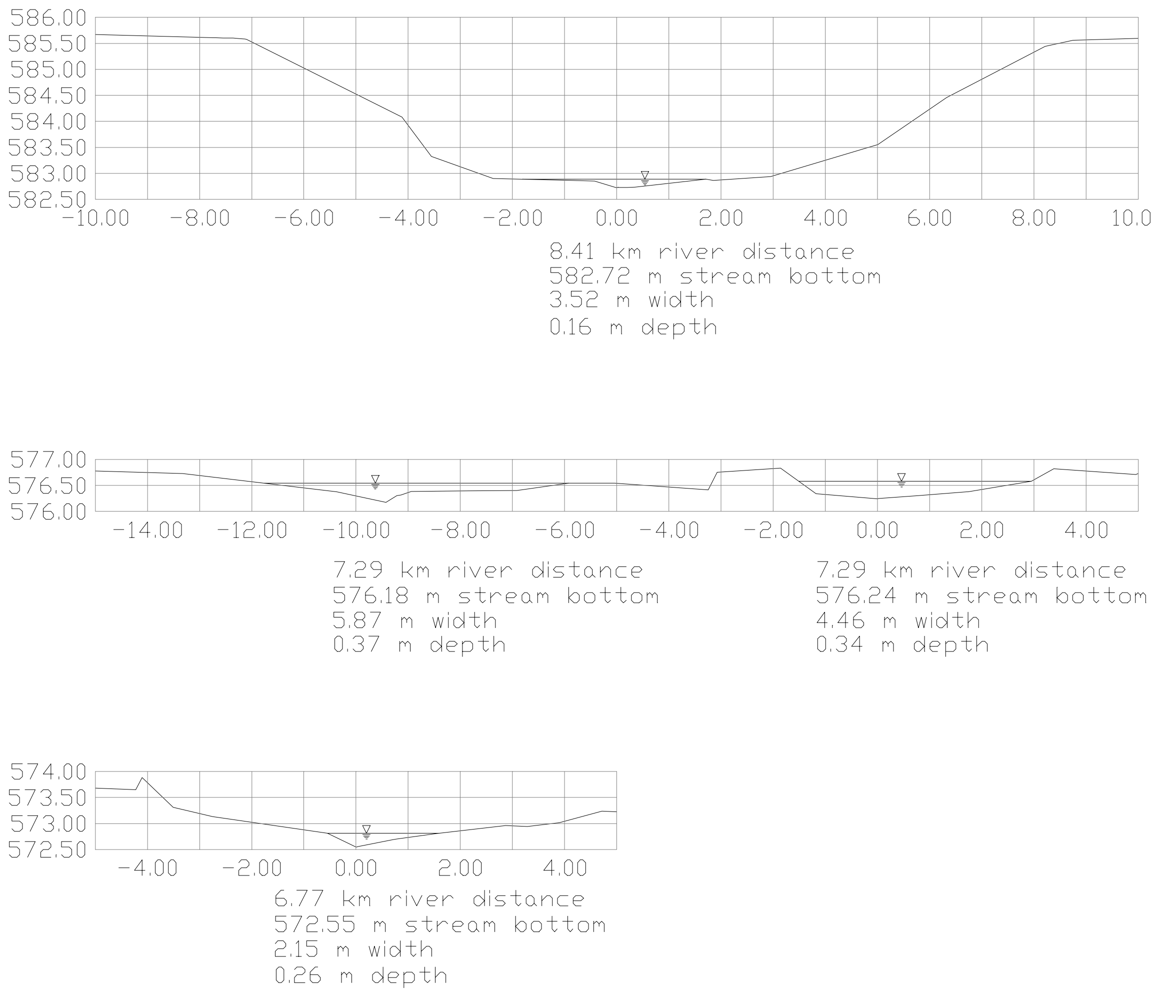


Figure 4. Gerking Creek bankfull estimation within Conservation Reserve Enhancement Program area. Flow is from page, vertical exaggeration is 2x. River distance is from Wildhorse Creek confluence, stream bottom is elevation.

grasses and forbs planted earlier in the project.

Discussion

The opportunity to study the riparian potential and channel morphology in an intensively managed agricultural setting, the Gerking Flat project, is unique. Riparian research has focused primarily in range and forest lands, which generally tend to have higher gradients with extensive land management practices, and a predominate focus on channel morphology and riparian area ecology (Bohn and Buckhouse, 1985; Kauffman et al., 1995; Belsky et al., 1999). Alternatively, croplands generally have low valley gradients, are managed more intensively by reworking the channel, plowing, and other crop production activities. Before crop production, these valleys were generally deposition areas for alluvial material. Previous riparian research in croplands has taken place in western Oregon and the midwestern and southern United States. This research has focused on extraction of nutrients from shallow groundwater (e.g., Griffith et al., 1997).

Van Haveren and Jackson (1986) reviewed concepts of riparian structure and function in range and forest lands during the last 25 years that serve as a useful guide to examine rehabilitation of riparian areas in croplands. In the Pacific Northwest, channel morphology research has focused on the impacts of logging in the Coast Range and Cascade Mountains of Washington and Oregon (Benda et al., 1997; Montgomery and Buffington, 1997), and the Sierra Nevada Mountains of California (Lisle, 1982). Unlike the mountain channels discussed in the research cited above, many channels on the Columbia Plateau are soft-bottomed silt-beds due to the deep alluvial and loess soils without shallow geologic control. Therefore, principles developed by Simon (1989, 1992, and 1995) in larger, soft-bottomed channels in west Tennessee might be more applicable to our conditions.

Gerking Creek is typical of many third order streams on the Columbia Plateau, in which the sinuosity was largely eliminated by channelization and the active flood plain is narrow and confined. This stream shape functions best for the efficient movement of water and soil from a site. It concentrates the stream energy even after management objectives have changed and a channel is no longer cleaned mechanically. Anecdotally, some local producers consider occasional high flows important for cleaning and improving the efficiency of similarly incised channels, especially those channels thick with cattails or dead weeds.

The incised channel into the project area will continue to be a source of considerable sediment and energy due to concentrated flow. Channel adjustment as a result of these flows can be expected to continue in the form of slope adjustment by upstream headcut migration, channel jumping to sites of pre-existing channels, and bank sloughing. These processes have the potential to remove physically newly planted material and to alter soil-water relationships across Gerking Flat. Whether soil deposited on the active flood plain by channel forming flows with return periods of 1.2 ~ 1.5 years (Richards 1982) can be washed away by flows with a return period of as little as 5 years is an open question in these streams.

Natural channels are dynamic; lateral movement, downcutting, and deposition are all natural processes. The goal of channel stabilization is not to create a channel wherein the channel never shifts in the floodplain or has a change in the channel slope. The purpose of channel stabilization in this project is to slow the movement of channel position to rates acceptable to the landowners and funding agencies. Channel stabilization also should result in absorbing stream energy so that channel banks and bottoms are not eroded downstream in a watershed.

Establishment of a healthy stand of riparian shrubs and trees in the incised channel will result in vegetation capable of damping the force of flood flows. The approach of planting three types of vegetation—which consist of low profile grasses and forbs, mid-stature shrubs, and trees—in addition to providing wildlife habitat, is to provide a foundation for structural enhancement of the stream channel. We expect the following scenario. Establishment of a grass community provides increased structural stability through root growth and increased roughness from stems. During high flows over the stabilized channel bottom: (1) energy transfers to stream banks, which begin to erode; and (2) sediment accumulates on the grassed terraces. As the high flows recede, the active channel has a decreased w/d ratio to carry low flows. The flood plain builds with subsequent high flows, in which energy is distributed across a wider, higher flood plain. On this aggraded flood plain, the establishment of shrubs and trees leads to increased roughness, further absorbing flood energy and increasing soil deposition. At the same time, energy is no longer concentrated in the low flow channel, is not causing downcutting, but allows deposition in the streambed. This process contributes to a decreased channel slope and flow rate. As bank cutting occurs and the active channel develops, sinuosity increases (stream length increases), and slope further decreases. These processes lead to a channel in dynamic equilibrium, which should migrate slowly back and forth across the flood plain.

In addition to withstanding destruction by high-energy flows, establishment of shrubs and trees requires adequate soil/water relations. The bottom of much of the incised channel remains damp throughout the year. This near saturated condition prohibits establishment of most grass and shrub species. Alternatively, because the soils in the valley are well drained but are above the channel bottom, the ground water level is well below the rooting zone on the abandoned flood plain (abandoned due to channel downcutting). The soil in Gerking Flat also is known to be salt affected. To create a zone in the soil profile that has appropriate soil/water conditions for trees and shrubs but is adequately drained to prevent the build up of salts, it might be necessary first to raise the streambed by designing and constructing the channel.

The presence of the secondary channel (confluence at 6.95 km) presents the potential to lose the sinuosity currently in the channel. An active headcut is apparent approximately 100 m from the confluence. Above the head cut is a nearly linear channel that has carried channel overflow from river station 7.40 km. If the headcut continues to migrate upstream, it will capture the current main channel. This event will reduce the stream length further through Gerking Flat, improving channel efficiency and increasing the rate of energy transfer downstream.

Changes in stream elevation and slope must take into account two culverts, one at the bottom or downstream end of the project and a second located approximately at the 8.20 km. At minimum, the culverts should have debris guards placed at the upstream entrances to prevent clogging by weeds and other debris. Incorporating these features into planned channel adjustments complicates the design process, but they are necessary to for successful implementation of the project. Alternatively, new culverts can be installed to accommodate the flow and expected stream changes. These changes might include culverts of a different design (elliptical rather than round) to fit within a shallower active channel, and with side culverts to accommodate high flows.

Conclusion

The Gerking Flat CREP project has the potential to result in reduced soil erosion and improved water quality and thus to have a positive impact on aquatic habitat within the watershed and to meet the landowners' desire to enhance wildlife habitat. As such, it is one of the first projects in a dryland-cropping region and will be watched closely by other landowners, who will judge its successes and failures. The Gerking Flat project also provides a unique opportunity to help develop and test research hypotheses concerning riparian and channel development in the croplands on the Columbia Plateau.

Literature Cited

Belsky, A.J., A. Matze, and S. Uselman. 1999. Survey of livestock influences on stream and riparian ecosystems in the western United States. J. Soil and Water Cons. 54(1): 419–431.

Benda, L.E., D.J. Miller, T. Dunne, G.H. Reeves, and J.K Agee. 1997. Dynamic landscape systems. *IN* Ecology and Management of Streams and Rivers in the Pacific Northwest Coastal Ecoregion. R. Naiman and R. Bilby, eds. Springer–Verlag, New York.

Bohn, C.C. and J.C. Buckhouse. 1985. Some responses of riparian soils to grazing management in northeastern Oregon. J. Range Manage. 38(4): 378–381.

Griffith, S.M., J.S. Owen, W.R. Horwath, P.J. Wignington, Jr., J.E. Baham, and L.F. Elliott. 1997. Nitrogen movement and water quality at a poorly-drained agricultural and riparian site in the Pacific Northwest. pp. 521–526. *IN* Plant nutrition—for sustainable food production and environment. T. Ando et al., eds. Kluwer Academic Publishers, Japan.

Kauffman, J.B., R.L. Case, D. Lytjen, N. Otting, and D.L. Cummings. 1995. Ecological approaches to riparian restoration in Northeast Oregon. Restoration & Management Notes 13(1):12–15.

Johnson, D.R. and A.J. Makinson. 1988. Soil survey of Umatilla County area, Oregon. USDA Soil Conservation Service, Washington D.C. 162 pp.

Lisle, T. 1982. Effects of aggradation and degradation on riffle-pool morphology in natural gravel channels, Northwestern California. Water Resources Research 18(6):1,643–1,651.

Montgomery, D.R. and J.M. Buffington. 1997. Channel-reach morphology in mountain drainage basins. Geol. Soc. Am. Bull. 109:596–611.

Richards, K. 1982. Rivers. Methuen & Co., New York. 361 pp.

Simon, A. 1989. A model of channel response in disturbed alluvial channels. Earth Surface Processes and Landforms 14:11–26.

Simon, A. 1992. Energy, time, and channel evolution in catastrophically disturbed fluvial systems. Geomorphology 5:345–372.

Simon, A. 1995. Adjustment and recovery of unstable alluvial channels: Identification and approaches for engineering management. Earth Surface Processes and Landforms 20:622–628.

Strahler, A. N. 1952. Dynamic basis of geomorphology. Geol. Soc. Am. Bull. 63:923–938.

Van Haveren, B.P. and W.L. Jackson. 1986. Concepts in stream riparian rehabilitation. Trans. 51st Amer. Wild. and Nat. Res. Conf.:280–289.

Zuzel, J.F. 1994. Runoff and soil erosion phenomena in the dryland grain growing region of the Pacific Northwest, USA. Trends in Hydrology 1:209–216.

Appendix 1. List of species to be planted in rehabilitation of riparian area of the Gerking Flat Project.

Trees:

- American plum / *Prunus americana*
- Black Cottonwood / *Populous Trichocarpa*
- Blue elderberry / *Ribus aureum*
- Choke cherry / *Prunus virginiana*
- Native willow / *Salix* sp. (on site)
- Nankin cherry / *Prunis tomentosa*

Shrubs:

- Bitterbrush, Antelope / *Purshia tridentata*
- Buckbrush / *Symphoricarpos orbiculatus*
- Fourwing saltbush / *Atriplex canescens*
- Greasewood / *Sarcobatus vermiculantus*
- Nookai rose / *Rosa nookia*
- Shadscale saltbush / *Atriplex confertifolia*
- Snowberry / *Symphoricarpos albus*
- Western clemati / *Clematis* sp.
- Woods Rose / *Rosa woodsii*

Grasses:

- Alkali sacaton / *Sporobolus airoides*
- Great Basin W R / *Elymus cinereus*
- Meadow foxtail / *Festuca eliator*
- Western wheatgrass / *Agropyron smithii*
- Streambank wheatgrass / *Agropyron riparium*
- Tall fescue / *Festuca arundinacea*
- Tall Wheatgrass / *Agropyron elongatum*

Legumes and forbs

- Alfalfa / *Medicago sativa*
- YBSC / *Meloilotus officinalis*